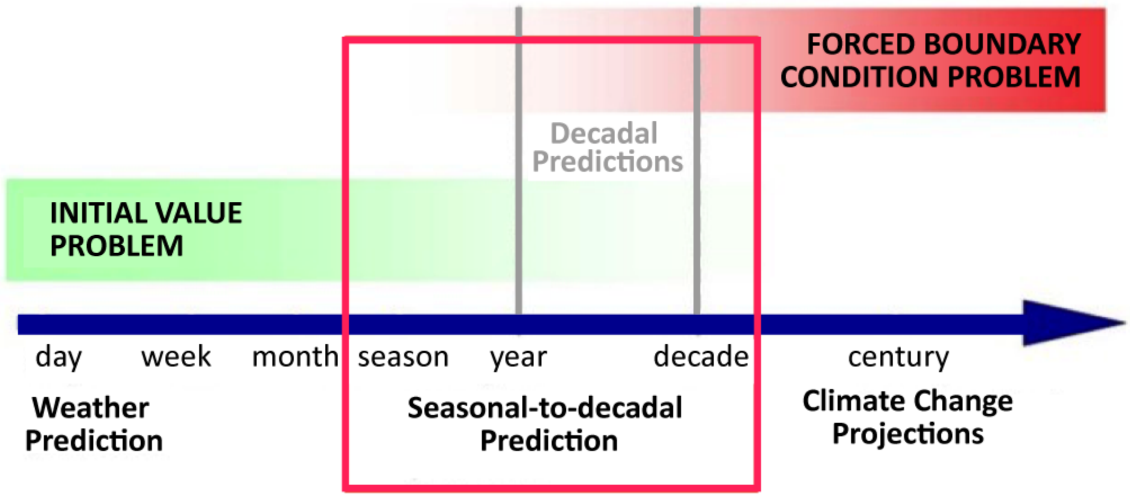
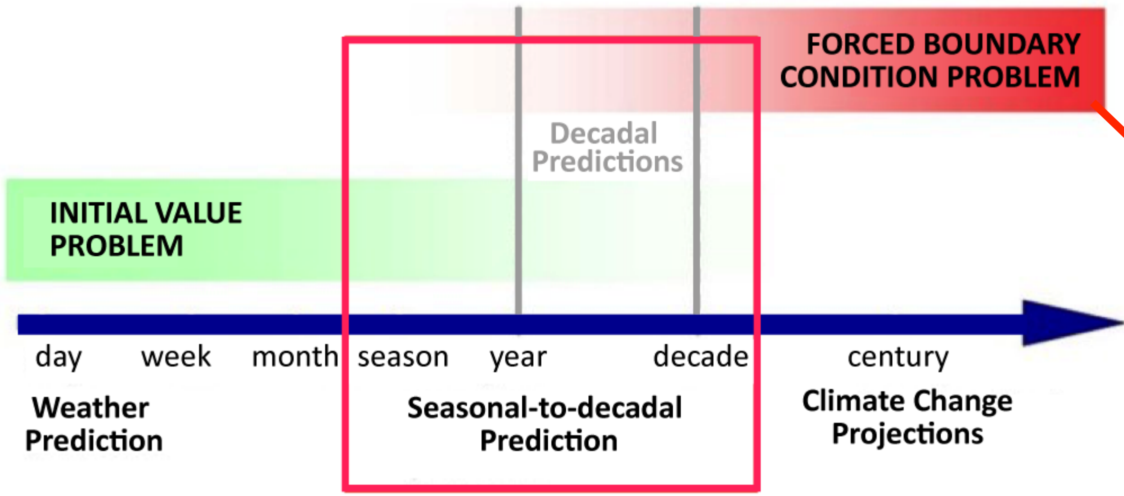
Cornerstones of climate prediction

Meehl et al 2009



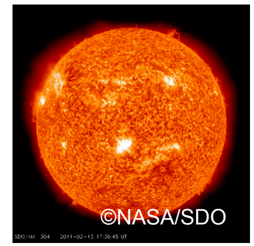
Cornerstones of climate prediction

Meehl et al 2009



Predictability relying on good guess of future changes in the forcing

Solar Activity

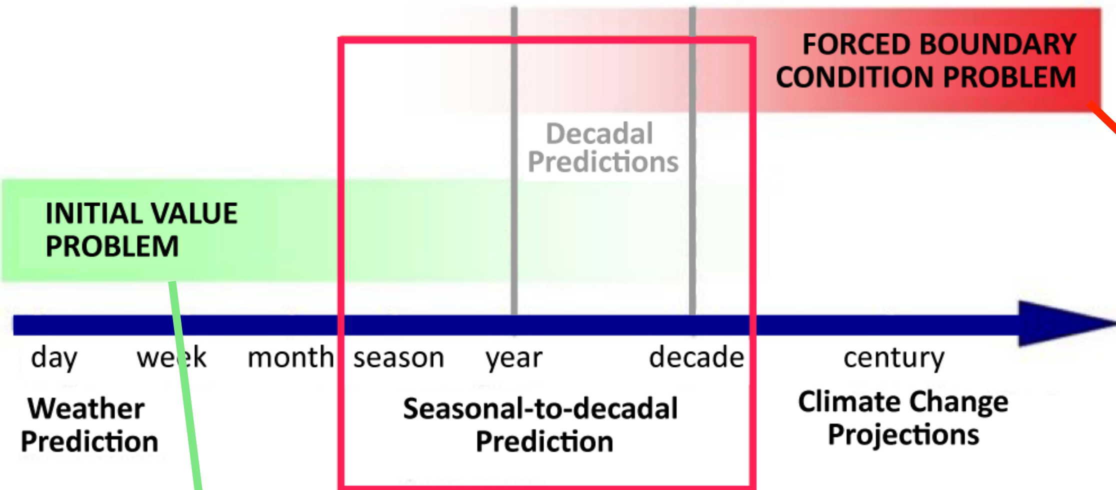


Volcanic Aerosols

GHGs

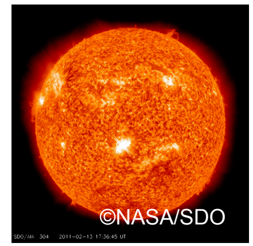
Cornerstones of climate prediction

Meehl et al 2009



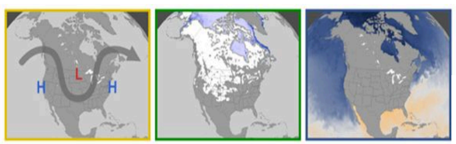
Predictability relying on **good guess** of future changes in **radiative forcing**

Solar Activity



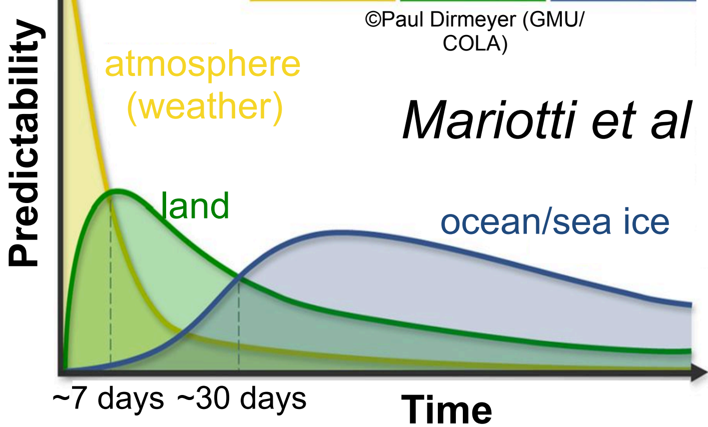
Volcanic Aerosols

GHGs



©Paul Dirmeyer (GMU/ COLA)

Mariotti et al 2018



Predictability arising from **memory** and **slow processes** in the different climate system components

Initial conditions in DCPP – r1i1p1f1

ATM:
Interpolated to model grid with IFS using prepIFS at ECMWF (now using openIFS at BSC)

Atmosphere reanalysis (**ERA 40 + Interim**)

Land reanalysis (**ERA-Land**)

LAND:
Offline land-surface simulation forced by bias-corrected ERA-Interim outputs

Kindly provided by Emanuel Dutra

Ocean + Sea Ice reconstruction (Assimilating **ORAS4**)

In-house reconstruction produced at BSC

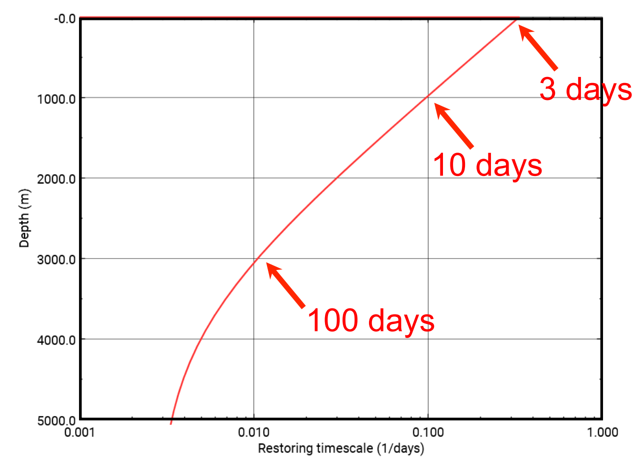
OCE + SI:
Historical reconstruction with NEMO-LIM stand alone, forced with ERA-40/Interim fluxes, and nudged globally towards 3D T and S from ORAS4

Default surface restoring coefficients

γ_T = **-40W/m²/K**

γ_S = **-150 kg/m2/s/psu**

Default 3D restoring timescales



Description of experiments

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Initialized Forecasts – r1i1p1f1

Atmosphere reanalysis
(ERA 40 + Interim)

Land reanalysis
(ERA-Land)

Ocean + Sea Ice reconstruction
(Assimilating **ORAS4**)

Start Date
1st November

Ensemble Size
10 members

Period Covered
1960-2018

Forecast range
10 years + 2 months

Historical+SSP2-4.5 Ensemble

Identified from different states in **picontrol** experiment r1i1f1p1

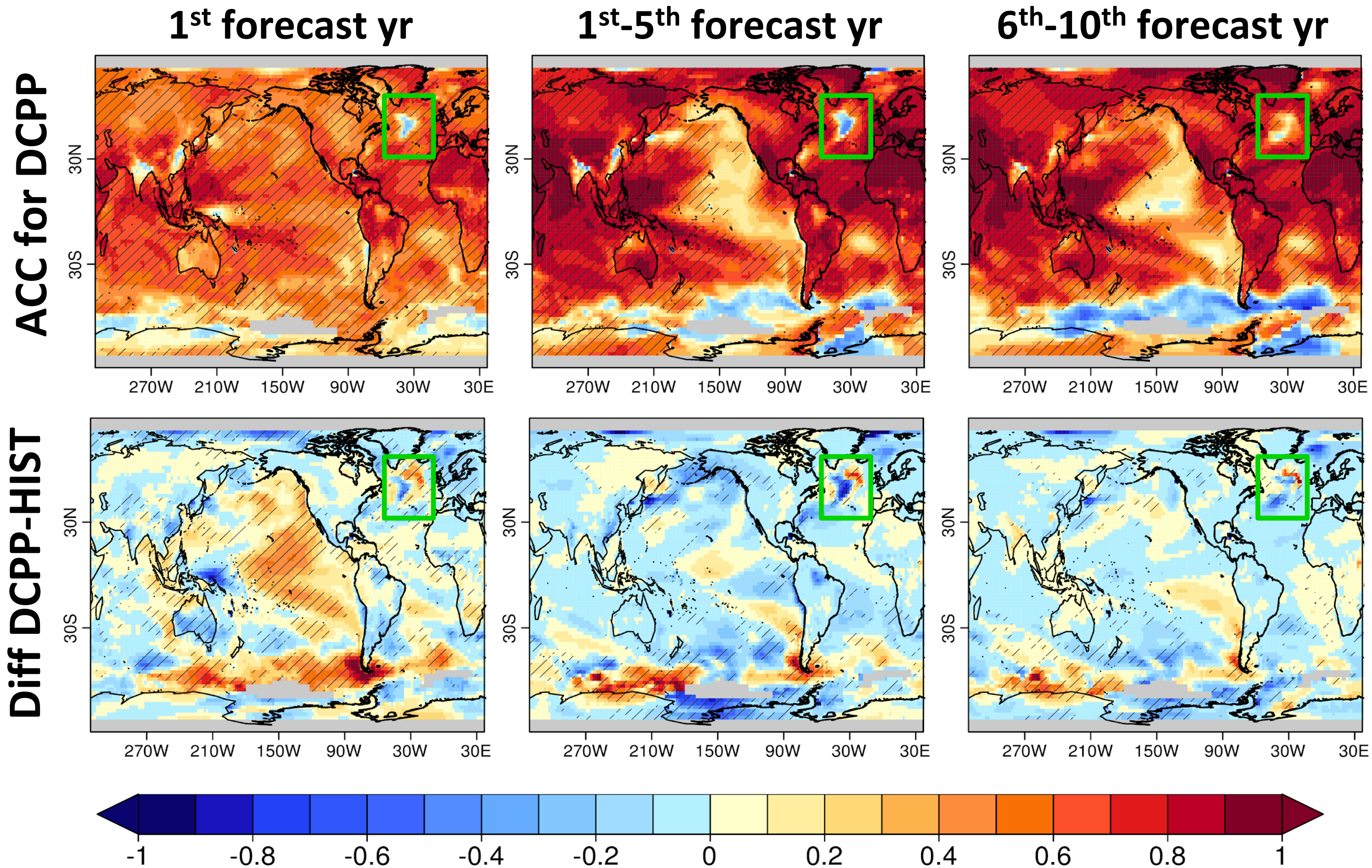
Ensemble Size
15 members
(the BSC ones)

Model Version
EC-Earth3.3.1 AOGCM

External Forcings (CMIP6)
Historical + SSP2-4.5 after 2014

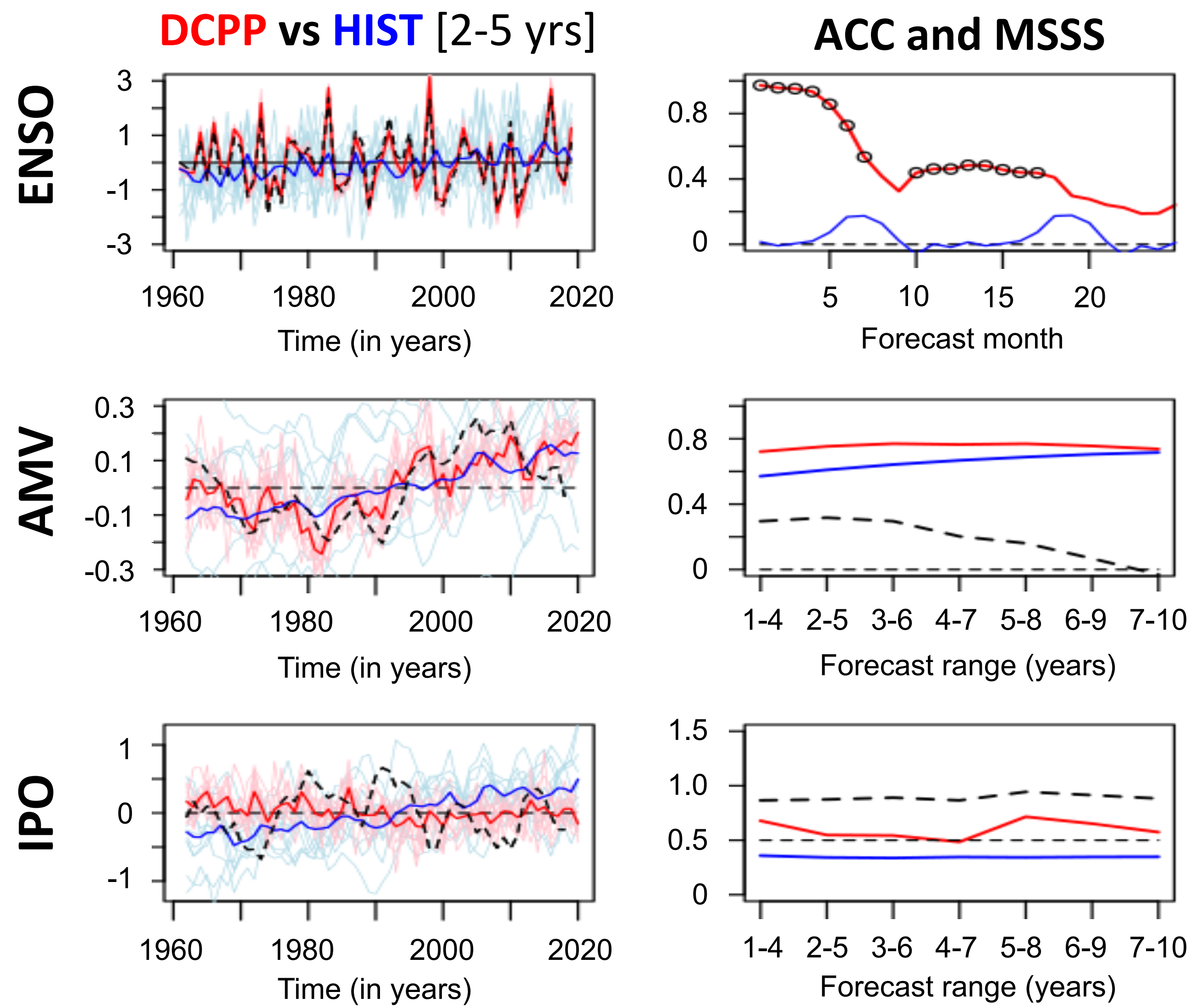
Skill in global surface temperature

Obs Ref: GHCN-ERSST-GISS



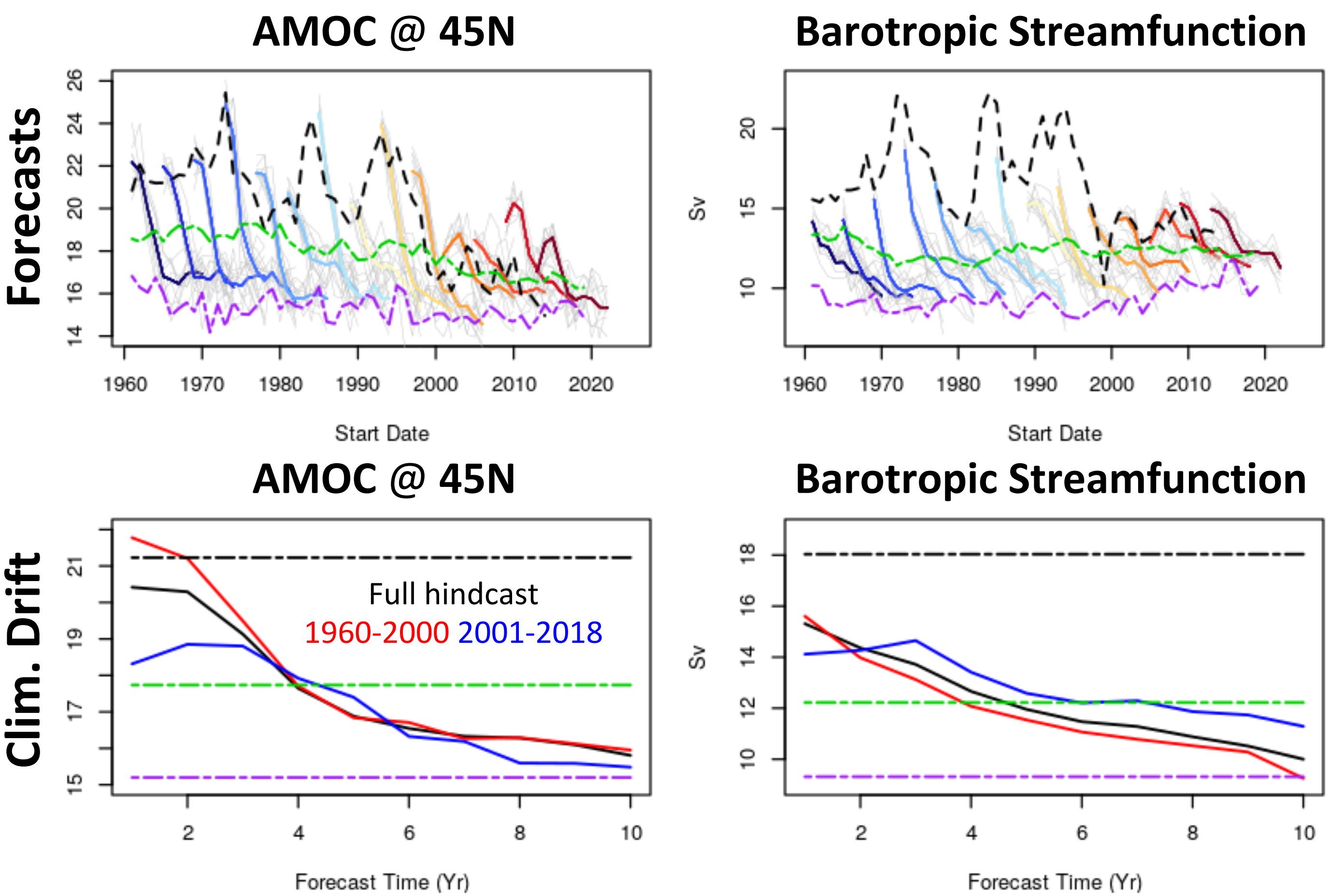
Little value of **initialization beyond year 1**, especially in the **North Atlantic**

Skill of key climate variability modes



All the three indices show **consistently higher skill in DCPP** at all forecast ranges, but it is **only significantly different for ENSO**

Ocean Circulation Indices



Blue to red:
DCPP ensemble mean

Grey:
DCPP members

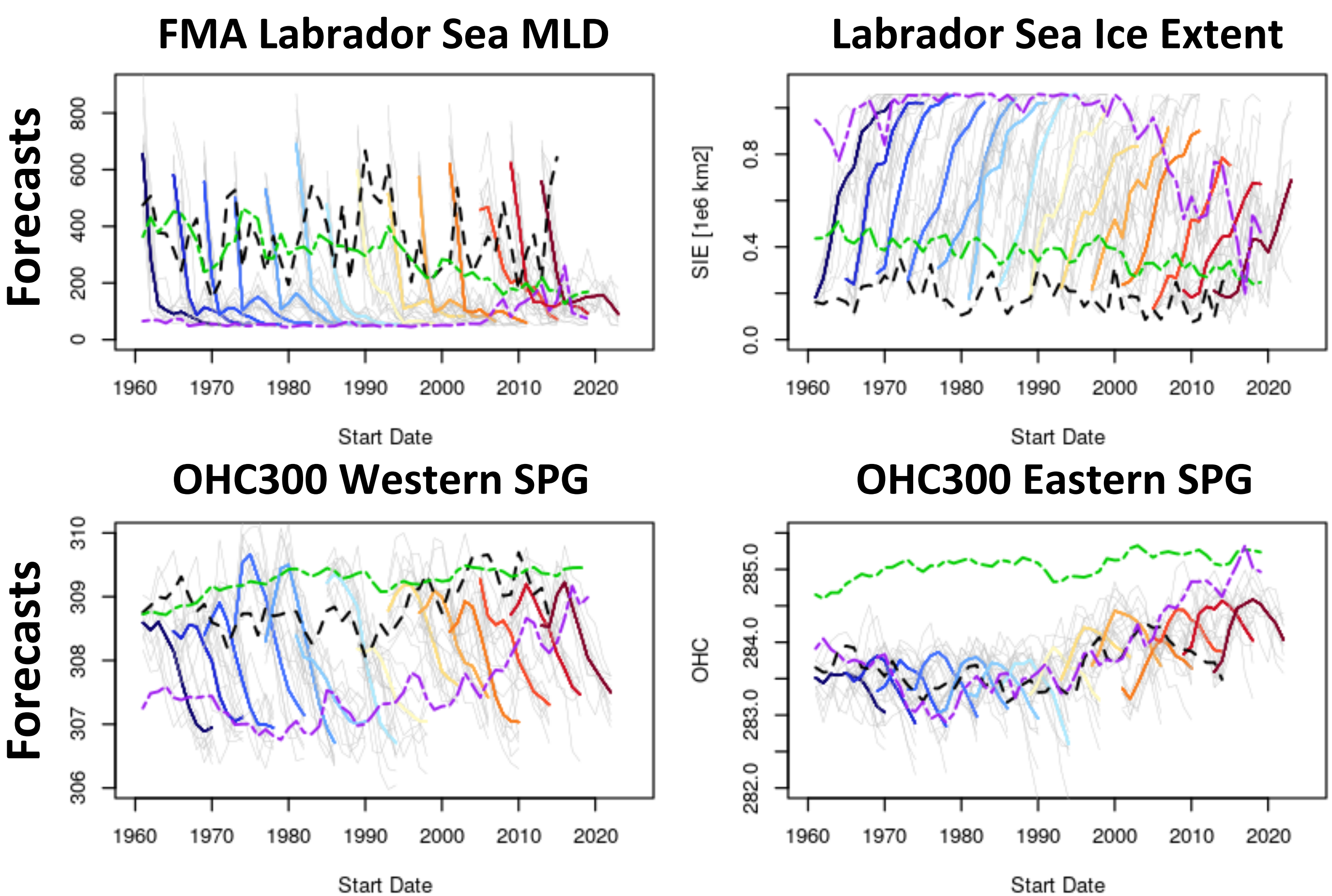
Green:
HIST with convection

Purple:
HIST no convection

Black:
RECONS (ICs)

Both indices start **stronger than** the systematic model state (**HIST**), suffer a rapid decline and oveshoot HIST. This **shock** is **weaker after year 2000**

Other North Atlantic Indices



Blue to red:
DCPP ensemble mean

Grey:
DCPP members

Green:
HIST with convection

Purple:
HIST no convection

Black:
RECONS (ICs)

The **shock** seems to be linked to a **shutdown of Labrador Sea convection**
Leading to quick **sea ice expansion**, and eventually affecting **SPG OHC300**

HIST vs DCPP in North Atlantic processes

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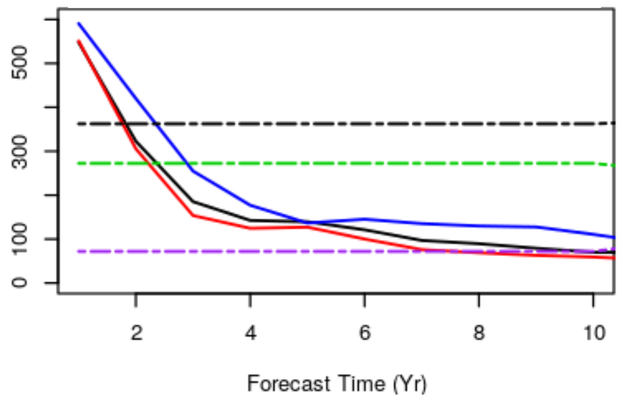
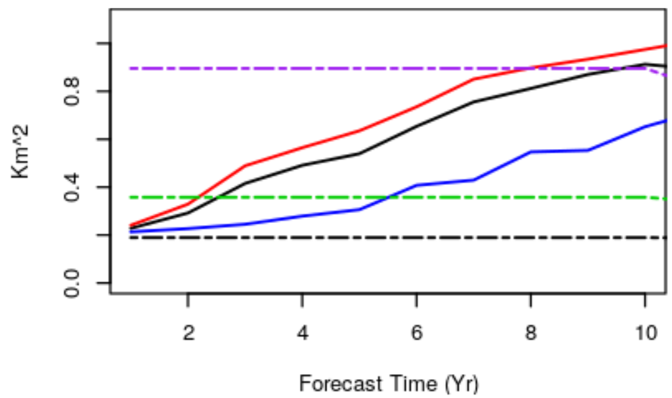
Other North Atlantic Indices

Clim. Drift

FMA Labrador Sea MLD

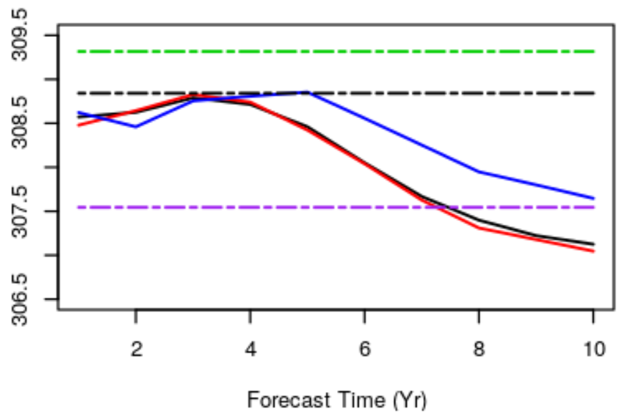


Labrador Sea Ice Extent

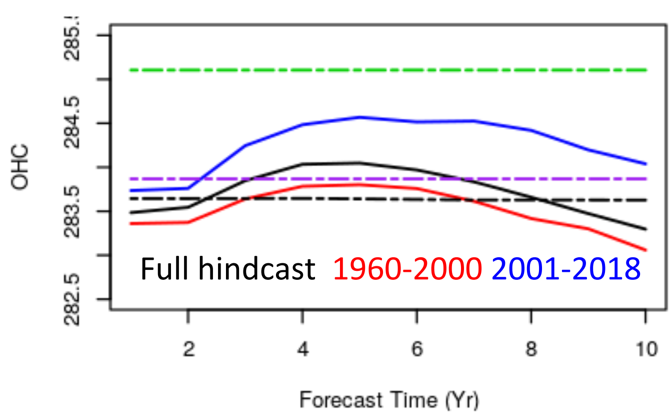


Clim. Drift

OHC300 Western SPG



OHC300 Eastern SPG



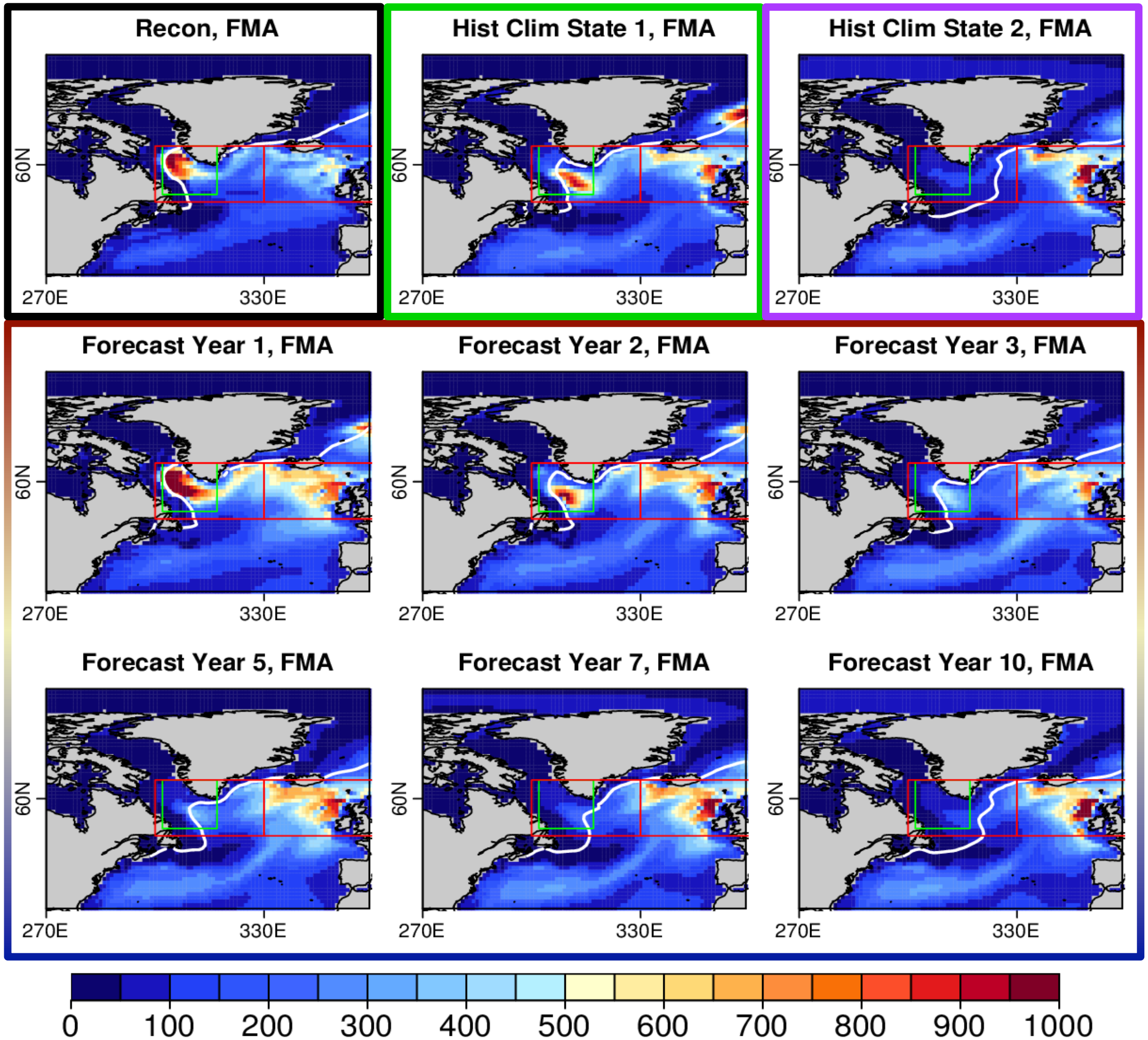
Green:
HIST with convection

Purple:
HIST no convection

Black:
RECONS (ICs)

We also notice **non-stationarity features in the drift**, which might be related or enhanced by the shock, and can be **limiting the predictive skill**

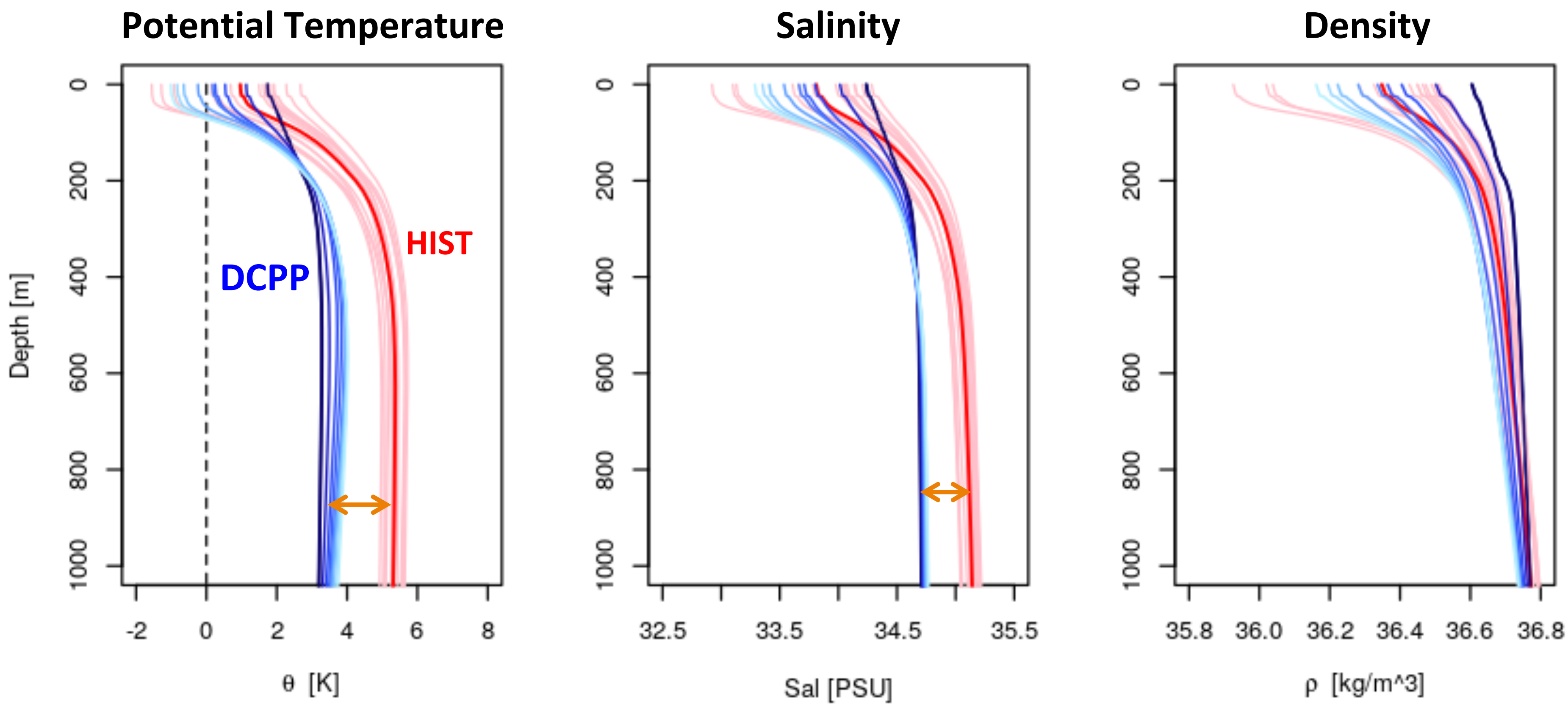
An anatomy of the North Atlantic shock



HIST runs can present either on/off Labrador Sea regimes, all weaker than **Recons**

In DCPP, convection greatly increases the first year, dying off in the next 2 years

Labrador Sea Stratification



Initialization brings the **predictions** to a **different stability state** than for **HIST in the Labrador Sea**, in particular at depth, a state that persists 10 years into the forecasts and that happens to **prevent the deep mixing**

Take-home messages

- **DCPP-BSC** restrospective forecasts (based on full-field initialization) show **little value of initialization beyond the first forecast year**
- The **North Atlantic** in particular, the key source region of decadal variability and prediction skill, shows **no clear significant benefit from initialization**
- This region is found to **experience a strong initialization shock**, which **shutdowns convection in the Labrador Sea after 3 years**, affecting other variables like local sea ice extent, or the OHC in the Subpolar North Atlantic
- This initialization shock is likely **linked to the intrinsic model variability**, which naturally alternates periods of active/suppresed Labrador Sea convection
- **Other alternative methods**, based on anomaly initialization, quantile matchig, or just reducing the nudging strength on Labrador region **are being**

Thank you!

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